REMARKS

Claim 1 calls for a coupling region between waveguides, at least one of the waveguides being segmented in the coupling region.

The office action suggests that the provision of a Bragg grating necessarily involves segmented portions of a waveguide.

However, in fact, Bragg waveguides are formed by writing ultraviolet light into the waveguide. Thus, the waveguide itself is in no way segmented in its physical structure. See the attached page from the book Fiber-Optic Communications Technology. Thus, there are no gaps or segmented regions as claimed in a conventional Bragg grating.

Therefore, reconsideration is respectfully requested.

Respectfully submitted,

Date: February 28, 2005

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Library of Congress Cataloging-in-Publication Data

Mynbaev, Djafar K.
Fiber-optic communications technology / Djafar K. Mynbaev, Lowell L. Scheiner.
p. cm.
Includes bibliographical references and index.
ISBN 0-13-962069-9
1. Optical communications. 2. Fiber optics
I. Scheiner, Lowell L. II. Title.

TK5103.59. M96 2001
621.382'75—dc21 00-044092

Vice President and Publisher: Dave Garza
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This book was set in Times Roman by The Clarinda Company. It was printed and bound by Courier Kendallville, Inc. The cover was printed by Phoenix Color Corp.

Prentice Hall

10 9 8 7 6 5 4 3 2 1
ISBN 0-13-962069-9

has a bandwidth of 0.2 nm; to get to 40 nm, one has to use a device about 1m in length. (Such FBG devices have indeed been fabricated.)

There is a trade-off between an FBG's bandwidth and its delay, that is, its compensation ability. For example, suppose an FBG introduces a 1400-ps/nm delay. This number means the FBG can introduce, theoretically, a delay of 1400 ps/nm over a 1-nm bandwidth or a delay of 140 ps/nm over a 10-nm bandwidth.

Fabrication of an FBG In 1978, Canadian scientist Kenneth Hill discovered fortuitously that the refractive index of the core of a fiber can be changed under exposure to ultraviolet light. This phenomenon, called *fiber photosensitivity,* is the physical basis for grating fabrication. There are two basic fabrication methods today: The original one—directly exposing a fiber's core to a pair of interfering UV beams—provides radiation of both maximum and minimum intensity. The minimum intensity leaves the refractive index unchanged and the maximum intensity changes the refractive index.

Hill and his colleagues also developed a second fabrication method—the phase-mask technique. Based on essentially the same interference principle, it gives much better results because of the higher grating precision it imposes.

In general, then, FBGs are considered the most promising dispersion-compensation devices. There are already many commercially available types of chirped-fiber Bragg gratings, and these seem to represent the direction in which the industry is going. FBGs are well on their way to giving DCFs stiff competition ([3], [6]). You can get an idea what commercial level the characteristics of chirped-fiber Bragg gratings have reached today by looking at the following data of a modern FBG [7]: bandwidth—from 4 to 10 nm; dispersion—from −700 ps/nm to −1400 ps/nm; insertion loss < 4 dB; PMD < 4 ps; PDL < 0.25 dB, and return loss (see Chapter 8) > 50 dB. The unit can compensate for third-order dispersion. The physical dimension is 212 × 155 × 20 mm.

Dispersion compensation is so important for long-haul systems that scientists continue to search for effective new solutions. Several competitive dispersion-compensating techniques are currently in the research stage.

Dispersion Compensation: The System Viewpoint

We have to keep in mind that we need to compensate for dispersion only for the purpose of increasing system bandwidth, or bit rate. But evaluation of dispersion-compensating devices should also take into account all other performance characteristics of a fiber-optic communications system. Let's consider dispersion compensation from the system standpoint.

In modern fiber-optic communications systems, dispersion—not loss—becomes the distance-limiting factor.

If we rearrange Formula 5.13 in such a way that

$$L_{max} = 1/\left[4BR|D(\lambda)|\Delta\lambda\right], \tag{6.11}$$

we can calculate the maximum length of a fiber link limited by chromatic dispersion. Let's take these typical parameters: $D(\lambda)$ = 17 ps/nm·km at λ = 1550 nm, $\Delta\lambda$ = 0.2 nm, and BR = 2.5 Gbps. One finds L_{max} (dispersion) = 29.4 km. Our calculations of loss-distance limitations in Example 5.2.1 showed L_{max} (loss) = 73.12 km. These numbers give you an idea of how dispersion-distance and loss-distance limitations relate to each other.

It seems that with improved dispersion-compensating techniques, this problem could be overcome. For example, for a DSF fiber, $D(\lambda)$ is not more than 2.5 ps/nm·km, which gives L_{max} = 199.9 km. Thus loss-distance limitation becomes the major restriction again. On the other hand, if one arranges the transmission of a high-power signal with in-line optical amplifiers, it looks as though the loss-distance limit disappears. In reality, however, both approaches do not allow us to achieve our goal. Pumping too much power into a fiber and working near a zero-dispersion wavelength cause other restrictions associated with nonlinear effects. These are discussed later in this chapter.